

National Aeronautics and Space Administration



TECHNOLOGY INNOVATION

MAGAZINE FOR BUSINESS & TECHNOLOGY

Volume 13 • Number 2 • 2006

Nanotechnology Paves Way for New Business Venture

PLUS

NASA Centers Win
R&D 100 Awards

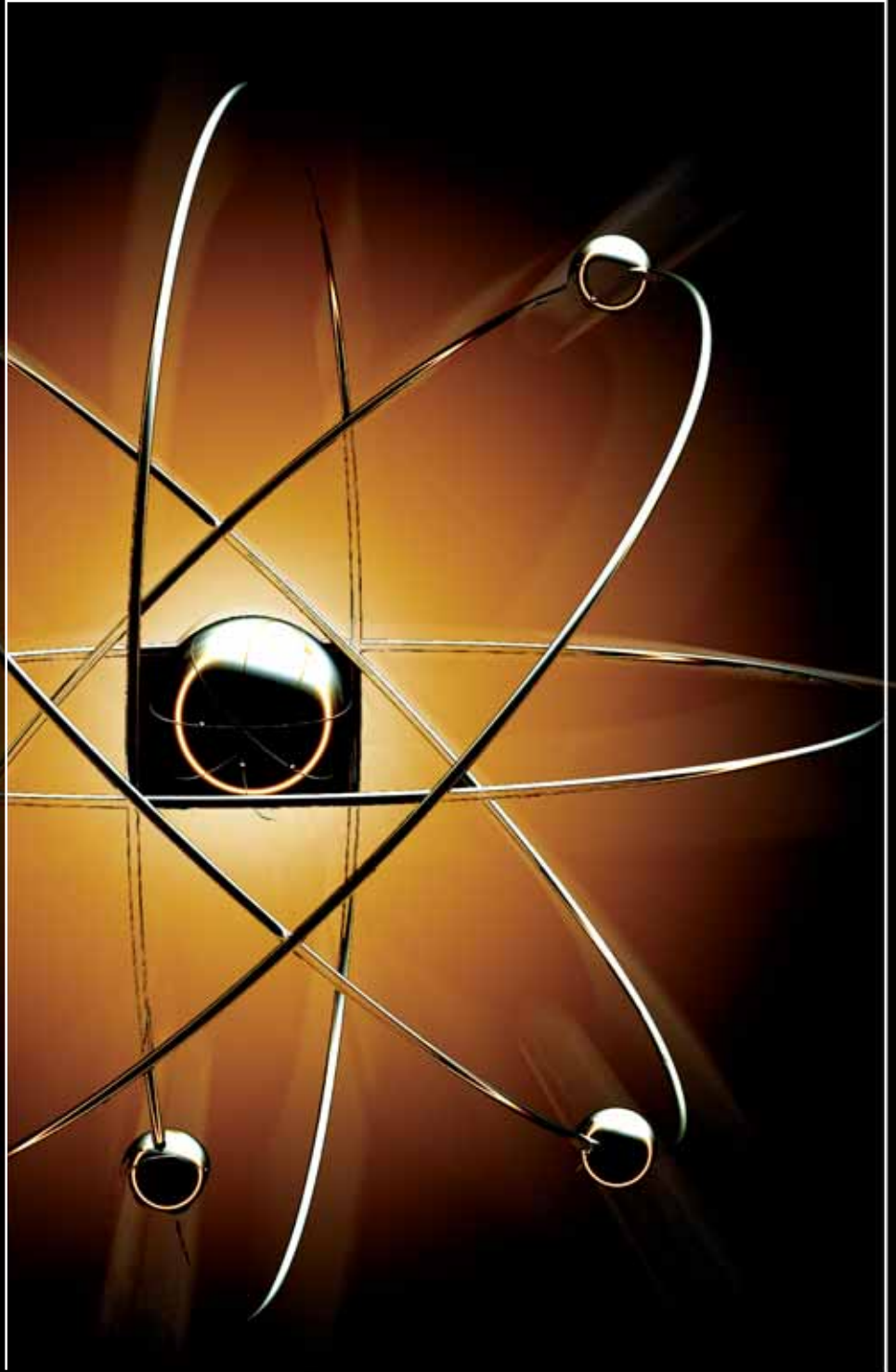
NASA and Universities
Join Fight Against
Diabetes

www.nasa.gov

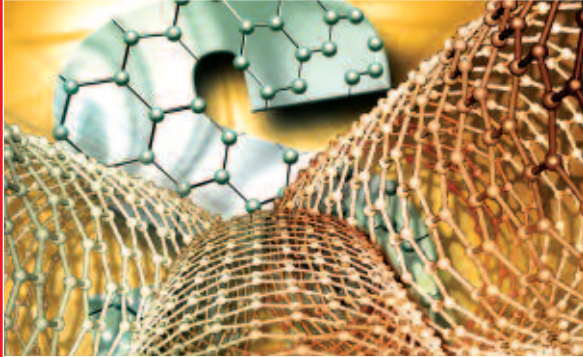
mysterious

The most beautiful thing we can
experience is the mysterious. It is
the source of all true art and science.

—Albert Einstein



COVER STORY



PAGE 12

NASA NANOTUBE TECHNOLOGY ENTERS THE COMMERCIAL MARKETPLACE

Single-walled carbon nanotubes are now available to university and industry researchers at a higher quality and lower cost than ever before, thanks to a technology developed at NASA Goddard Space Flight Center.

feature articles

20



NASA CENTERS WIN R&D 100 AWARDS

The 44th annual R&D 100 Awards recognized four NASA centers for excellence in research and development innovation. The technologies demonstrated in the world-wide competition are among the most innovative ideas from academia, government and industry.

24



NASA TO PARTNER WITH AIRLAUNCH LLC ON SMALL SATELLITE DEVELOPMENT

Exploring collaborations in space launch systems and payloads launched from aircraft is the main objective of a new partnership between NASA and AirLaunch LLC. The two entities recently signed a memorandum of understanding for the joint venture.

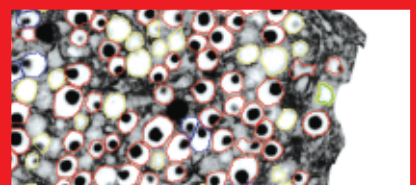
26



NASA AMES AIR TRAFFIC MANAGEMENT TOOL WINS SOFTWARE OF THE YEAR AWARD

NASA software designed to help improve the safety and efficiency of the national airspace system has been recognized for its innovation and significant contributions to science and technology.

32



NASA AND UNIVERSITIES JOIN FIGHT AGAINST DIABETES

A NASA image processing technology used to explore orbital images of Earth and distant worlds is being modified for diabetes research. The technology will provide new tools for fighting the disease.

departments

To view online and for past issues, visit
<http://www.ipp.nasa.gov/innovation>



PAGE 6

THE SPACE FOUNDATION HAS RECOGNIZED ZEOPRO AS A CERTIFIED SPACE TECHNOLOGY. ZEOPRO™ IS A COMBINATION GROWTH MEDIUM, FERTILIZER AND SOIL AMENDMENT THAT ENHANCES PLANT GROWTH BECAUSE OF ITS PATENTED NUTRIENT DELIVERY SYSTEM. ONE OF ITS PRIMARY INGREDIENTS IS A SLOW RELEASE FORM OF PHOSPHOROUS AND OTHER KEY ELEMENTS DEVELOPED BY NASA.

FACILITY FOCUS

Highlighting NASA Goddard Space Flight Center's
 Detector Systems Facility

INNOVATIVE RESEARCH

An example of how NASA is working
 with small business

6

NASA NEWS BRIEFS

The latest happenings from NASA's technology transfer and industry-related areas.

11

LOOKING BACK

Foot Comfort for the Fashionable

17

OPPORTUNITY FOR PARTNERSHIP

NASA Technology Opportunities for private companies

30

36

PAGE 30



A NASA EMPLOYEE WORKS WITH THE MASK ALIGNERS AND WAFER BONDER AT GODDARD SPACE FLIGHT CENTER'S DETECTOR SYSTEMS FACILITY. THESE LABS AT GSFC ARE AVAILABLE FOR USE BY OTHER GOVERNMENT, ACADEMIC OR COMMERCIAL ENTITIES.

CHIEF EDITOR
Janelle Turner

MANAGING EDITOR
Michele Rejonis

RESEARCH
Michele Rejonis

ART DIRECTOR/PRODUCTION
Dennis Packer

ONLINE EDITORS
Kathryn Duda
Michele Rejonis

CONTRIBUTORS
Sheri Beam
Nona Minnifield Cheeks
Kevin Cook
Kathryn Duda
Nancy Pekar
Carl Ray
Laurel Stauber
Liz Ward
Lisa Williams

Technology Innovation is
published bi-annually by the NASA
Innovative Partnerships Program.
Your feedback provides
important contributions
to this publication.

To provide comments or input, or to
be added to our regular distribution,
please visit our Web site:
www.ipp.nasa.gov/innovation

Material from this publication
MAY be reproduced without the
permission of the publisher.

UPFRONT with...

Nona Minnifield Cheeks

Chief, Innovative Partnerships Program
NASA Goddard Space Flight Center



EXPECT THE UNEXPECTED

James Joyce once wrote, “A man of genius makes no mistakes. His errors are volitional and are the portals of discovery.” Like many others working in scientific research and development, I believe this to be true. Part of what makes a person successful in research—and, indeed, in life—is viewing a “mistake” as an opportunity. An opportunity to learn, to grow and in some cases, to make a discovery that can change our understanding of the world. Making the most of unexpected opportunities is part of the entrepreneurial spirit at NASA. This is readily observed by studying some examples from a single NASA center: Goddard Space Flight Center (GSFC) in Greenbelt, Md.

A mathematical error was the starting point for an award-winning discovery by Dr. Norden Huang, who recently received the prestigious Service to America Medal. As part of his research in oceanography, Huang stumbled upon a new way to analyze signals from naturally occurring phenomenon. Called “one of the most important discoveries in the field of applied mathematics in NASA history,” the *Hilbert-Huang Transform* (HHT) technology enables a better understanding of naturally occurring phenomena.

Goddard also was the breeding ground for one of this year’s R&D 100 Awards: the *Conformal Gripper*, developed by John Vranish, a retired NASA researcher. This innovation—which gently conforms to any object’s shape then locks into position for an extremely secure yet gentle hold—is poised to revolutionize robotics. By eliminating the need for multiple, specialized grippers, this tool can make robots used in space missions lighter and less complicated as well as offer benefits to manufacturing and medical surgeries.

But most exciting is Goddard’s Dr. John C. Mather, who received the 100th Nobel Prize in physics along with George Smoot of the Lawrence Berkeley National Laboratory. The prize was given for their collaborative work on understanding the Big Bang theory of the universe and the origin of stars and galaxies. That work was conducted as part of the Cosmic Background Explorer (COBE)—a satellite built entirely at GSFC.

These honors and the countless others received by researchers at Goddard—as well as across the Agency—are only part of what makes NASA an ideal partner for conducting collaborative research. At Goddard, for instance, our award-winning personnel are working in unique facilities with state-of-the-art equipment, such as the Detector Development Laboratory (see Page 30). This facility and others of its kind allow industry, academia and government organizations to benefit from the nation’s investment in the space program.

The return on that investment also is embodied in our innovative technologies. Beyond the award-winning HHT and *Conformal Gripper* mentioned above, as well as the technologies described in this edition’s Opportunity for Partnership, Goddard is leading the way in cutting-edge technologies. These innovations not only benefit the space program, but also can accelerate developments in medicine, energy, transportation, the environment, manufacturing, telecommunications, consumer products and more.

As we pursue our journey to evolve innovative technologies, join NASA in our search for portals of discovery that push the frontiers in space and on Earth. You can start by contacting Goddard’s Innovative Partnerships Program office to find out where your journey aligns with ours.



NASA News Briefs

NASA Plant Food Technology Improves Lawn and Garden Care

The Space Foundation announced recently that ZeoPro™ from ZeoponiX Inc., is officially recognized as a Certified Space Technology. ZeoPro is a combination growth medium, fertilizer and soil amendment that enhances plant growth because of its patented nutrient delivery system. One of its primary ingredients is a slow release form of phosphorous and other key elements developed by NASA. ZeoPro is available to individuals exclusively from Advanced Soil Science at retail nurseries and garden centers and through Internet and catalog companies.

“The Space Foundation is pleased to certify ZeoPro,” says Kevin Cook, director of space technology awareness for the Space Foundation. “ZeoponiX and distributor Advanced Soil Science are working to make the benefits of this environmentally-friendly technology available to every gardener.”

NASA developed a new kind of growth medium for plants (called *zeoponic materials*) that carries within itself the nutrients needed by plants and provides those nutrients in a very efficient manner. ZeoponiX holds exclusive rights to the NASA patents and further developed the technology



THE SPACE FOUNDATION HAS RECOGNIZED ZEOPRO AS A CERTIFIED SPACE TECHNOLOGY. ZEOPRO IS A COMBINATION GROWTH MEDIUM, FERTILIZER AND SOIL AMENDMENT THAT ENHANCES PLANT GROWTH BECAUSE OF ITS PATENTED NUTRIENT DELIVERY SYSTEM. ONE OF ITS PRIMARY INGREDIENTS IS A SLOW RELEASE FORM OF PHOSPHOROUS AND OTHER KEY ELEMENTS DEVELOPED BY NASA.

in ZeoPro, an ecologically friendly product that enables indoor and outdoor plants to determine when they need nutrition, delivering a balanced diet of slow released plant nutrients.

ZeoponiX is working closely with Advanced Soil Science to make ZeoPro available to everyone who wants to make their home greenhouse, houseplant, flower bed, vegetable garden or lawn grow vigorously. ZeoPro uses essential plant nutrients more efficiently with various soil structures, while being environmentally responsible. Advanced Soil Science is the exclusive distributor of ZeoPro to the thousands of gardeners, retail garden centers, Internet retail garden supply companies and other

horticultural outlets within the United States.

About the Space Certification Program

Since the dawn of the space era, the world's best engineers at NASA and other space agencies have been developing advanced technologies that fuel space exploration and also result in a number of applications that improve life on Earth. The Space Certification Program, managed by the Space Foundation in cooperation with NASA, provides official recognition for qualified products and services incorporating those space technologies. For more information, visit www.SpaceConnection.org.

NASA TECHNOLOGY TRANSFER AND INDUSTRY-RELATED NEWS

About the Space Foundation

Founded in 1983 and headquartered in Colorado Springs, the Space Foundation is a national nonprofit organization that vigorously advances civil, commercial and national security space endeavors and inspires, enables and propels tomorrow's explorers. The Space Foundation has offices in Washington, D.C., and Cape Canaveral, Fla. ■

For more information, visit www.spacefoundation.org.

Please mention that you read about it in *Technology Innovation*.

NASA Ames Licenses Program and Data Management Software to Industry

NASA and JumpStart Solutions are working together to bring software developed for use in the nation's space program directly to consumers and commercial markets.

Through a recently signed agreement, JumpStart Solutions, Cave Creek, Ariz., will license NASA's *Program Management Tool* (PMT), *Query Based Document Composition* (QBDC) and *NETMARK* software.

The *Program Management Tool* is a comprehensive, Web-enabled, business application tool. It is designed to monitor, disseminate and track the progress of research and development programs and to project milestones. The tool operates in conjunction with *QBDC* and *NETMARK*. *NETMARK* is an information-on-demand framework that manages, stores and retrieves unstructured and/or semi-structured documents. *QBDC* is a tool that enables content or context searches, either simple or hierarchical, across a variety of databases. *NETMARK* is a revolutionary concept in information management. Along with *PMT* and *QBDC*, *NETMARK* was invented and developed at NASA Ames Research Center, Moffett Field, Calif.

JumpStart Solutions has indicated that it plans to integrate other technologies with *PMT/NETMARK* to provide project portfolio management and knowledge document management capabilities for its industry, university and other customers.

"We recently granted a non-exclusive patent and copyright license to an Arizona company to develop new software based on the *Program Management Tool/NETMARK* technology developed at NASA Ames," says Martha Del Alto, technology partnership manager at NASA Ames. "This agreement represents a continuation of NASA's com-

mitment to transfer technology to the commercial marketplace."

JumpStart Solutions LLC is a technology company that licenses and commercializes select, well-developed technologies sourced from federal government and university research centers. ■

For more information, contact Martha Del Alto, (650) 604-4865, mdelalto@mail.arc.nasa.gov.

Please mention that you read about it in *Technology Innovation*.

Ames Technology Helps Improve Industrial Plant Safety and Efficiency

NASA is partnering with industry to develop a new health monitoring system to increase safety and efficiency in complex industrial plants, such as power generation and water treatment facilities.

The new industrial plant health monitoring system will be based on the *Inductive Monitoring System* (IMS), a technology developed at NASA Ames Research Center, located in California's Silicon Valley. The *IMS* technology uses artificial intelligence and data-mining

NASA News Briefs

techniques to build system-monitoring knowledge bases from archived or simulated sensor data to detect unusual or anomalous behavior that may indicate an impending system failure. The *IMS* currently is helping analyze data from systems that help fly and maintain the space shuttle and the International Space Station. Previously, the *IMS* has been used by NASA's hybrid combustion facility, an advanced rocket fuel test facility, the RASCAL UH-60 Blackhawk helicopter, and to monitor engine systems on an F/A-18 Hornet aircraft.

"We recently granted a non-exclusive patent license to a local company to develop new software based on the *IMS* technology developed at NASA Ames," says Phil Herlth, technology partnership manager at NASA Ames. "This agreement represents a continu-

ation of NASA's commitment to transfer technology to the commercial marketplace."

"We have integrated the NASA technology into our Remote Manager software platform to provide a complete early warning and diagnostics software for the process industries," says Peter Millett, CEO of iSagacity Inc., of Half Moon Bay, Calif. According to Millett, the NASA technology will greatly enhance the capabilities of its Web-based monitoring products, such as Remote Manager.

"The combination of the NASA technology with our algorithms already in place in Remote Manager provides an unprecedented capability to identify potential problems in almost any type of process before the equipment fails," Millett says. "The problem in many industries

has not been a lack of sensor data, but the ability to make sense of it all in a time frame that can support operations."

iSagacity is an engineering and software company that provides a suite of software applications to monitor and analyze operating data from critical equipment and systems in the process industries. ■

For more information, contact Phil Herlth, (650) 604-0625, pherlth@mail.arc.nasa.gov.

Please mention that you read about it in Technology Innovation.

GSFC Signs Partnership Agreements

The Office of Technology Transfer (OTT) at Goddard Space Flight Center, Greenbelt, Md. has announced the signing of four partnership agreements.

National Institute of Standards and Technology

Under a memorandum of understanding with the National Institute of Standards and Technology (NIST), researchers from Goddard and NIST will be able to work together using joint expertise and NIST's state-of-the-art nanotechnology fabrication facilities to further their individual and



NASA TECHNOLOGY TRANSFER AND INDUSTRY-RELATED NEWS

joint research goals.

OTT facilitated the development and signing of the agreement, which enables collaboration between Goddard and NIST researchers to further advances in nanotechnology. The agreement is also expected to save taxpayer money by enabling Goddard scientists to use NIST's new \$350 million research facilities rather than duplicate these facilities at NASA.

"By having access to these state-of-the-art facilities and capabilities at NIST, Goddard can focus its resources on the validation of these miniaturized technologies to accelerate their maturity for spaceflight applications supporting scientific research and NASA's vision for space exploration," says Goddard's chief technologist Peter Hughes.

The agreement calls for the two organizations together to define and manage research projects in nanoscience and microelectromechanical systems (MEMS) device design, technologies, operational protocols, fabrication technologies and device metrology for use in chemical and biological detectors, power generation, thermal management systems, radio frequency electronics, electro-optic devices and distributed sensor networks.

The collaborative research could have far-reaching benefits for many scientific areas. "Specific progress can be made in radiation-tolerant memory

devices for all space missions, biological sensors to detect the presence of life at distant bodies, and multi-functional materials for next-generation robotics and vehicles," Hughes says. "The applications and target mission uses in this emerging technology area are diverse, compelling and exciting."

Maryland's Department of Business and Economic Development

In the future, the Maryland state motto could become "To Boldly Go" with some of NASA's forthcoming exploration efforts having a very home-grown feel. That's because of the agreement Goddard signed with DBED to attract high-technology companies to the state.

The agreement enables collaboration between Goddard and DBED. The mutually beneficial agreement will help bolster economic growth in Maryland while helping to support NASA missions. The agreement also will help supplement Goddard's research skills by facilitating technical exchanges with local organizations to study new aerospace trends, methods and challenges that may benefit NASA missions.

"DBED can certainly help us bolster the skills and expertise at Goddard by bringing technology collaborators with similar research interests to the state," says OTT chief Nona Cheeks. And by leveraging local technical labor and education

resources, Goddard may also strengthen its strategic technical advantage.

The State of Maryland stands to reap significant benefits from the agreement as well. With a strong interest in stimulating local economic growth, DBED can leverage collaboration with Goddard to demonstrate educational, financial and business resources that technology companies require. "We can help each other," says Cheeks. "DBED can help us find scientists in industry that may help us further our missions. And at the same time, by demonstrating the need for those researchers in Maryland, we can help DBED meet some of its economic milestones."

The agreement calls for the two organizations to collaboratively develop outreach programs, workshops and other meetings related to Goddard's technology needs. Goddard also will provide DBED with information related to its facilities and technological expertise that will be of interest to technology companies. In turn, DBED will facilitate collaboration between Goddard researchers and regional labs, as well as academic and business organizations, to develop joint technology ventures.

Smithsonian Astrophysical Observatory

Researchers at the Smithsonian Astrophysical Observatory (SAO) conduct laboratory experiments to study and

NASA News Briefs

measure cross-sections for electron impact excitation in multiply-charged ions. This process is the source for all light from the sun; however, most cross-sections for producing light in the extreme ultraviolet (EUV) range are known only from theoretical calculations. Experimental data are needed to validate the theoretical methods, to understand the processes, and therefore to explain the distributions in the intensities and wavelengths of the sun's light.

Because such experiments require mirrors that can reflect and focus light over a wide range of wavelengths, SAO turned to Goddard as the space-optics leader. Not only had Goddard researchers developed an innovative coating that allows a mirror to efficiently reflect light from the red wavelengths down to the EUV range, but Goddard had the thin-film coating facility to do it.

"Goddard is the only place in the country that does this kind of coating," explains SAO physicist Larry Gardner. "We could have tried to make do with a commercial coating, but they're significantly less efficient. If we weren't able to access Goddard's facilities, it would have taken us four times as long to get the data we need. It has a big impact on our ability to do the experiments."

This work was performed under a new type of Space Act Agreement—that

is, a Simplified SAA. "The Simplified SAA represents a new, faster process for routine work of a limited scope," says Scott Owens, who is technology coordinator for Goddard's Optics Branch. "This template agreement can be routed through the legal and financial systems in a matter of weeks."

University of Baltimore

Liberal arts, law and business students at the University of Baltimore now have the opportunity to work directly with Goddard researchers and technologies through the school's Lab to Market program. As part of the program, students assess Goddard technologies and collaborate with university faculty and Goddard researchers to develop commercialization plans and potential licensing opportunities.

The agreement will enhance NASA's strategic technology objectives, providing Goddard with assessment information about potential applications and licensing opportunities for possible technology transfer efforts. As described by OTT's Monica Montague, "Goddard can benefit tremendously from the assessments the university students will conduct for our technologies. Using their insights, we'll be able to better understand additional applications and licensing opportunities."

The University of Baltimore's Center for Technology Commercialization (CTC) facilitates the commercialization of technologies from federal labs using a cross-disciplinary team approach. The Lab to Market program has been added to this list of collaborative efforts that teach hundreds of students to apply their knowledge and skills to real technologies.

Through the partnership with Goddard, the students gain hands-on experience with technology assessments and market-development plans. The agreement enables students and faculty to choose a set of Goddard technologies to work with for a semester. Teams of at least four students analyze an assigned technology using intellectual property (IP) audits, brainstorming, security analyses, economic feasibility, development of return on investment and other collaboration with researchers. Final reports from the teams are made available to Goddard and include arguments for their analyses, technology/market assessments, identification of IP issues, competition, market analyses, potential applications and other valuable data. ■

For more information, contact NASA Goddard's Office of Technology Transfer, (301) 286-5810, techtransfer@gsfc.nasa.gov.

Please mention that you read about it in Technology Innovation.

Looking Back

A FOLLOW-UP ON A NASA SUCCESS

Foot Comfort for the Fashionable

Modellista Footwear's new shoe line takes comfort to a level that is out of this world. The company, headquartered in Wellesley Hills, Mass., achieved this feat with Tempur® material, a special foam originating from NASA research that was later refined by Tempur-Pedic Inc. Modellista uses the foam in their exclusive Tempur PRT insoles, which conform to each wearer's unique foot shape to absorb shock and cushion the foot. The foam's properties allow the shoe to change with the wearer's foot as it shrinks and swells throughout the day.

Scientists at NASA's Ames Research Center originally developed temper foam in the early 1970s to relieve the intense pressure of G-forces experienced by astronauts during rocket launches. In the following years, temper foam was used in wheelchairs, football helmets, airplane seats and X-ray table pads. In the 1990s, the foam attracted increased attention when Tempur-Pedic Inc., further developed it for their Tempur-Pedic Swedish Sleep System,™ a line of mattresses and pillows.

Tempur material consists of billions of open, spherical-shaped cells that are viscoelastic, meaning solid with liquid properties. This viscoelastic property, in addition to the foam's temperature and weight sensitivity, enable the cells to shift position and reorganize to conform to body contours. The material softens in warmer areas where the body makes the most contact with the surface, and remains firmer in cooler areas, where less contact is made. By absorbing and evenly distributing a body's weight over its surface, the material

eliminates uncomfortable pressure points. Modellista's David Froment, inspired by the comfort of Tempur-Pedic's mattresses, sought to bring Tempur material to footwear. After acquiring a license from Tempur-Pedic, Froment and his team conducted 22 months of research and development. During that time, they overcame a problem that other shoemakers interested in the Tempur material had failed to solve. Traditionally, steam is used to shape shoes. Since Tempur material's extreme sensitivity to heat and moisture causes it to deflate upon contact with steam, Froment's team needed to develop an entirely new process. They devised a way to form the shoes without

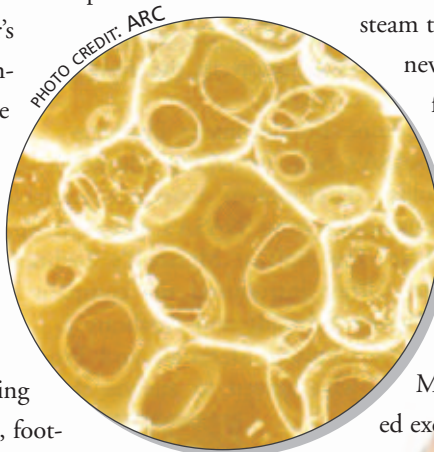
steam that does not harm the material. Even with this new process, the challenge to protect the material from the effects of hot, sweaty feet remained.

To solve that problem, an antibacterial lining was incorporated into the shoe, designed to wick away heat and moisture. Froment's research ultimately paid off with a colorful line of shoes built on a clog platform.

Froment's main goal in developing the Modellista line was to design a shoe that provided exceptional comfort without sacrificing style. He noted that all too often, health care professionals and chefs who are on their feet all day resign themselves to less attractive shoes in

exchange for comfort. While Modellista offers an industrial line of shoes for these workers, every Modellista shoe provides the same amount of Tempur material padding. The difference in the industrial line is a stain resistant leather upper to protect the shoes against betadine, blood, urine and other damaging elements.

The Modellista collection is the first shoe design and construction to be certified by the Space Awareness Alliance. The shoes, with designs ranging from traditional clog shapes to sling backs and open-toe sandals, are currently available nationwide at select stores and through various catalogs. ■



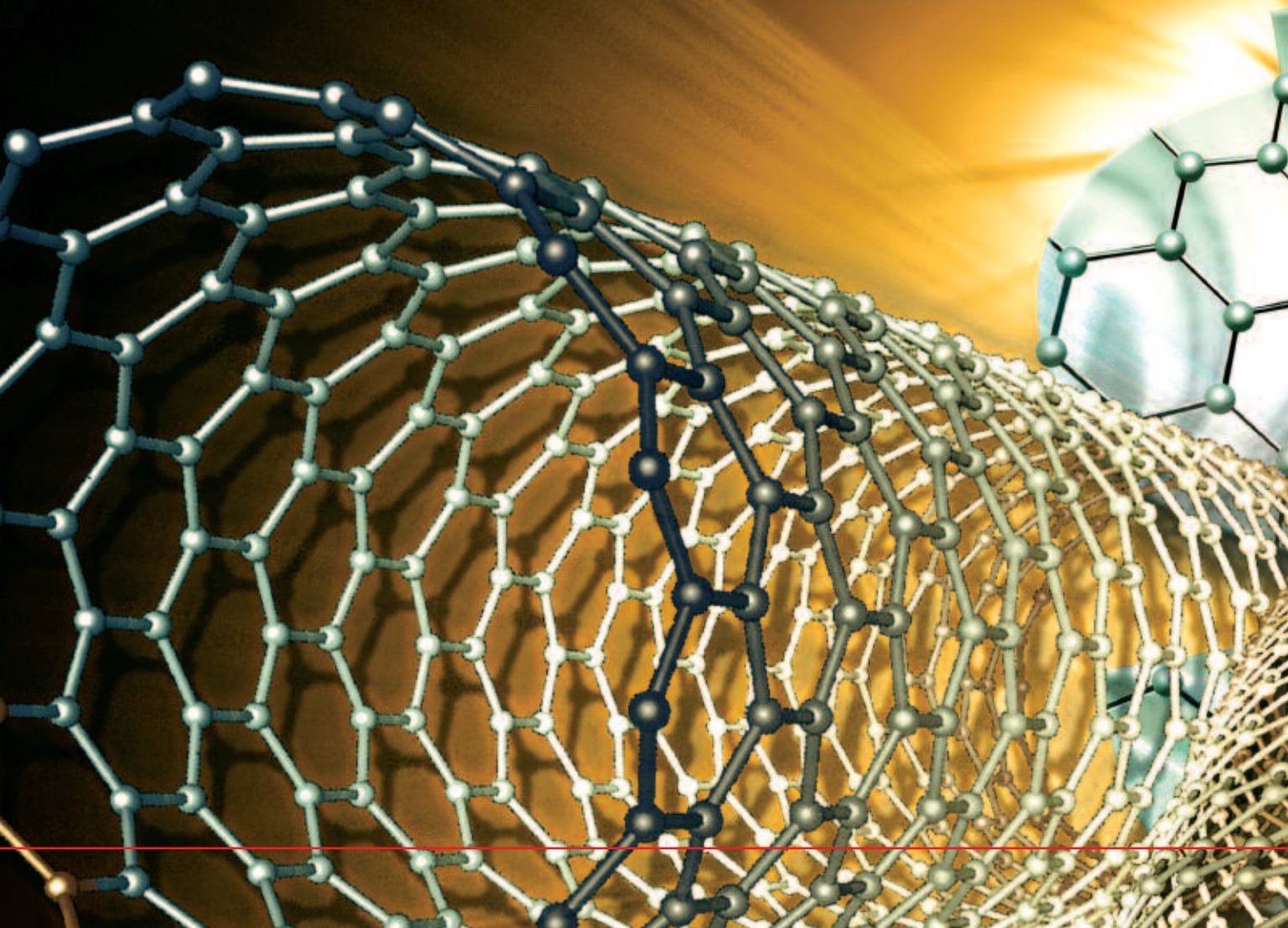
THE CELLS IN TEMPUR® MATERIAL ARE SOLID WITH LIQUID PROPERTIES, ALLOWING THEM TO CONFORM TO BODY CONTOURS.

cover story

Nanotechnology

NASA NANOTUBE TECHNOLOGY

ENTERS THE COMMERCIAL MARKETPLACE

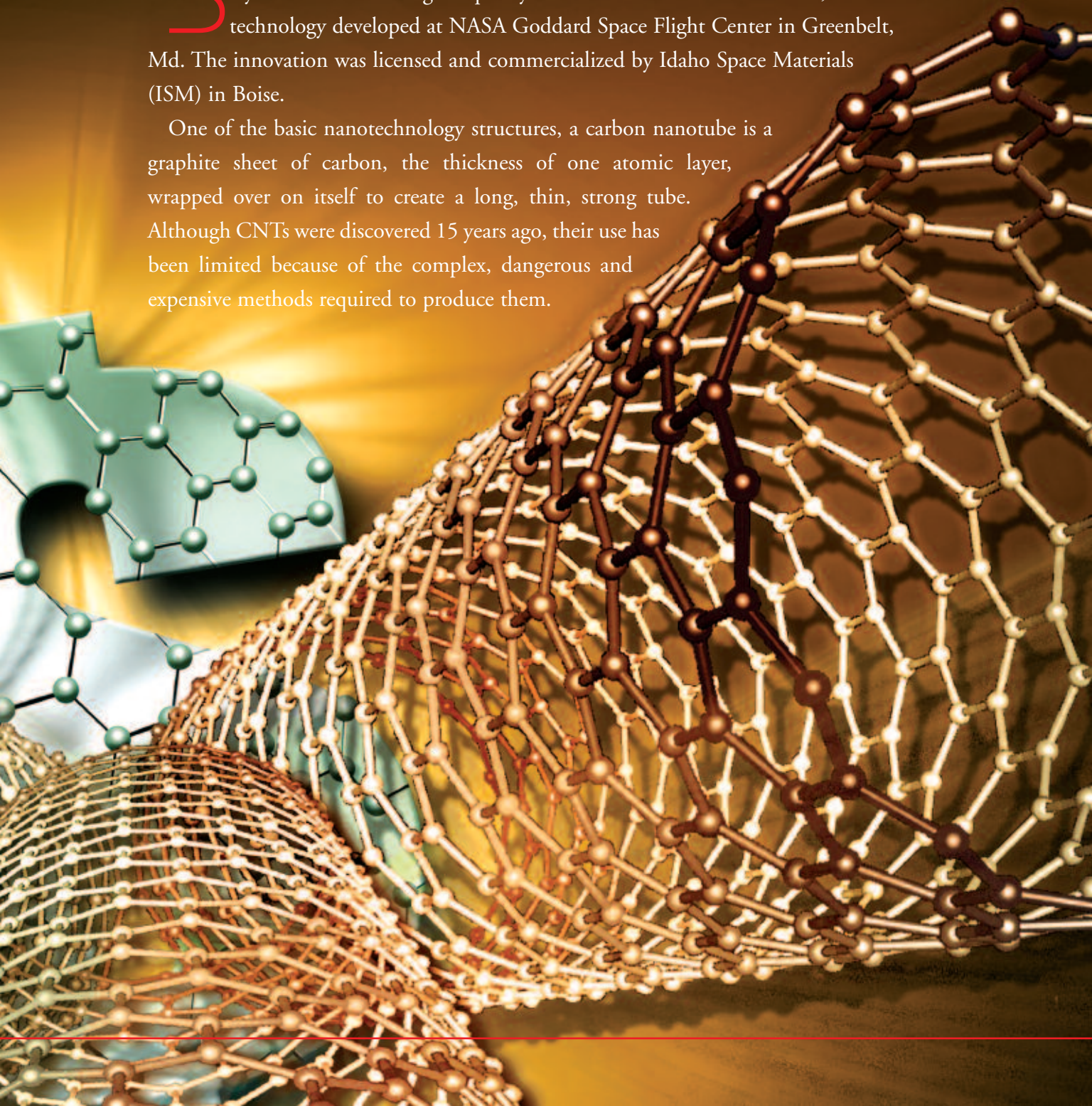


By Nona Minnifield Cheeks

Big things are happening in nanotechnology.

Single-walled carbon nanotubes (SWCNTs) are now available to university and industry researchers at a higher quality and lower cost than ever before, thanks to a technology developed at NASA Goddard Space Flight Center in Greenbelt, Md. The innovation was licensed and commercialized by Idaho Space Materials (ISM) in Boise.

One of the basic nanotechnology structures, a carbon nanotube is a graphite sheet of carbon, the thickness of one atomic layer, wrapped over on itself to create a long, thin, strong tube. Although CNTs were discovered 15 years ago, their use has been limited because of the complex, dangerous and expensive methods required to produce them.



Most methods, including chemical vapor deposition, laser ablation, microwave and high-pressure CO conversion (HiPco), use a metal catalyst to encourage carbon to grow in nanotube form without capping. However, the use of a metal catalyst dramatically increases the pre- and postproduction costs.

Those drawbacks were eliminated, however, when NASA Goddard Researcher Dr. Jeannette Benavides developed a simpler, safer, and much

Given the *SWCNT* technology's wide range of applicability, Goddard's Innovative Partnerships Program office began promoting it at conferences, in print and online in search of a licensee.

NASA's new process caught the attention of entrepreneur Wayne Whitt, who was seeking an innovation with which to start an advanced materials company. Believing that the NASA process was an ideal fit, he founded ISM in December 2005 and

provided ISM with feedback on variations in its manufacturing process, allowing procedures to be improved. ISM later obtained a Raman spectroscopy system from Kaiser Optical Systems to perform in-house characterization of nanotubes.

Once ISM's production process had been perfected, the company launched its commercialized *SWCNTs* as NOMEK 1556 in August 2006, and began supplying them to university researchers at a reduced price.

"Licensing NASA's technology allowed us to begin operations and rapidly commercialize an innovative product without the traditional R&D costs and time," says Whitt. "We were able to focus on process enhancement and commercialization, which resulted in significant improvements in yield and production capacity without sacrificing product quality."

Because the new process does not use a metal catalyst, no metal particles need to be removed from the final product. Eliminating the presence of metallic impurities results in the *SWCNTs* exhibiting higher degradation temperatures (650°C rather than 500°C) and eliminates damage to the *SWCNTs* by the purification process.

A helium gas shield is used to protect the nanotubes from foreign material contamination while they are being formed. Distilled water is employed as a cooling medium to protect the production equipment, since the arc discharge method gener-

...NASA Goddard Researcher Dr. Jeannette Benavides developed a simpler, safer, and much less costly process for manufacturing *single-walled CNTs* without the use of the metal catalyst.

less costly process for manufacturing *single-walled CNTs* without the use of the metal catalyst. Benavides' innovative method produces higher yields of better-quality CNTs, while dramatically reducing costs associated with removal of impurities.

NASA believed that its improved production process could increase the prevalence of carbon nanotube technology in many areas, including medical applications such as portable/field equipment, implantable biosensors, artificial limbs and organs, and drug delivery; miniature and consumer electronics; research instruments (e.g., microscopy); fuel cells; radiation shielding; and innovative polymers.

applied for a nonexclusive license for the new technology. As license negotiations moved forward, Benavides met with ISM officials to demonstrate and fully explain the technology. The license agreement was signed in March 2006.

ISM enhanced NASA's process, boosting yield and production capacity. As part of these efforts, the company worked with the Electron Microscopy Center at the University of Idaho, which had the specialized equipment needed to characterize ISM's nanotube specimens. University researchers also called upon the expertise of Benavides in performing the Raman spectroscopy on ISM's samples. The characterization data



INVENTOR DR. JEANNETTE BENAVIDES SETS UP THE PROCESS FOR MANUFACTURING THE SINGLE-WALLED CNTs WITHOUT THE USE OF THE METAL CATALYST.

ates temperatures in excess of 4000°C.

The nanotubes agglomerate, or collect, during formation, and are dispersed afterward by a milling procedure. The milling equipment is coated with zirconium oxide to provide a durable material that will withstand extraordinary strength of the nanotubes.

Whereas traditional catalytic arc discharge methods produce an “as

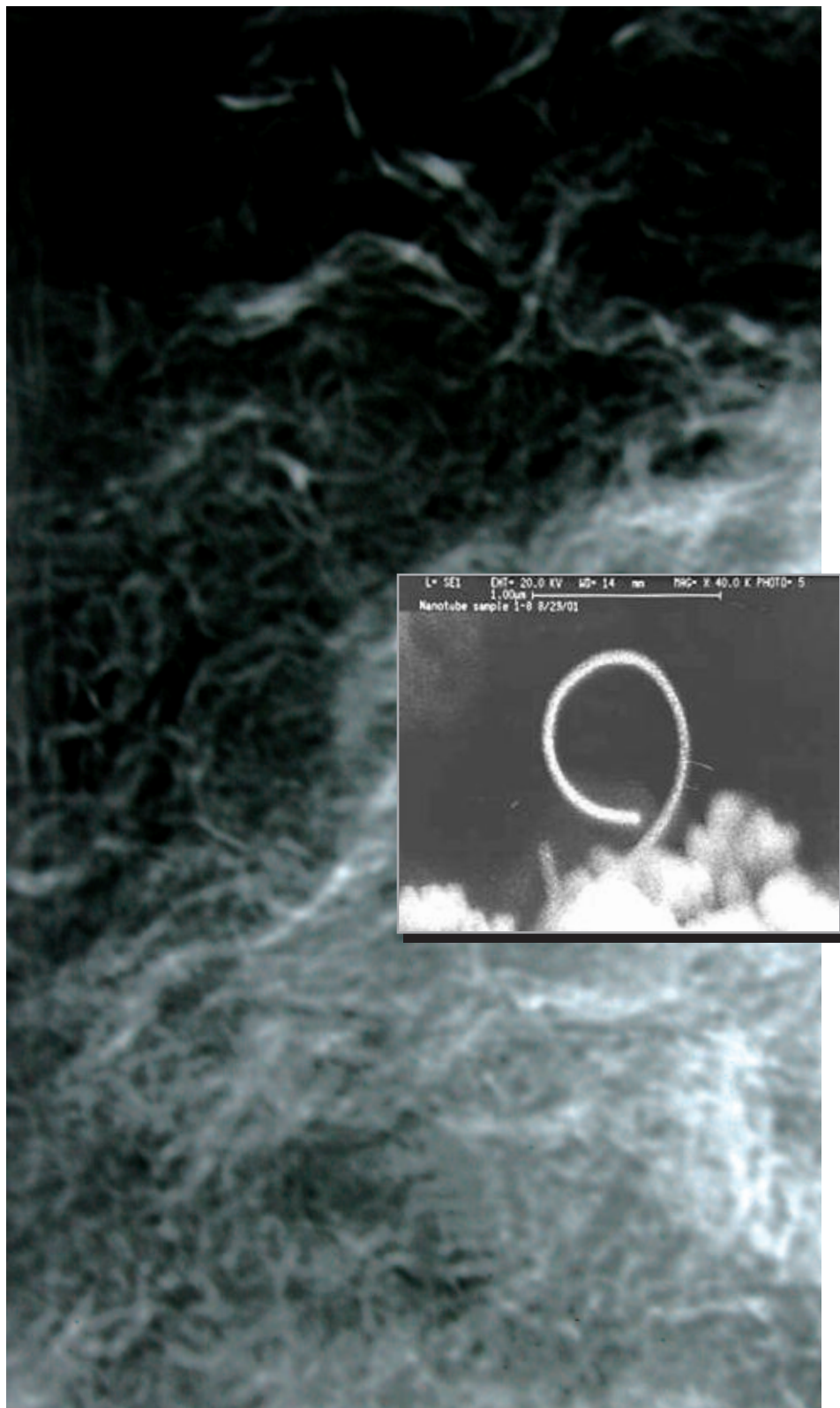
prepared” sample with a 30-50 percent *SWCNT* yield, the new method produces *SWCNTs* at an average yield of 70 percent.

ISM can produce *single-walled CNTs* at a rate of 50 grams per hour and can scale manufacturing infinitely to match consumer demand. The company expects the high production rates to facilitate research into new uses for *SWCNTs*.

“ISM believes that carbon nan-

otubes will be a building block for a better world, making people’s lives better through a wide range of uses, including medical advances, fuel cells, video displays, solar cells and a host of other applications,” explains ISM vice president Roger Smith. “Getting *single-walled CNTs* into the hands of researchers will help accelerate their transition from a conceptual idea to a practical product.”

“I’m very excited to see that this



A MICROGRAPH OF NANOTUBES IS SHOWN, WHILE THE INSET PHOTO DEPICTS A CURLED TUBE.

agreement is now making CNTs more readily available, particularly for academic and other research programs,” says Benavides. “The fact that they now have access to lower-cost CNTs bodes well for the future of nanotechnology.”

In addition to benefiting the research community and the general public, the transfer of the NASA technology has stimulated economic development. The transaction resulted in the creation of a new advanced materials company and eight high-tech jobs in Boise. By the spring of 2007, ISM expects to have increased its staff to 20.

NASA also will see positive results. The diffusion of the Agency’s patented technology, and ISM’s sales of the resulting products, generates revenue that NASA can reinvest in space program research. And NASA now has a source from which to purchase low-cost, high-quality *SWCNTs* for use in space exploration and science missions.

This technology transfer success story was made possible by the efforts of NASA’s Innovative Partnerships Program, which has a two-part focus: forming partnerships between NASA and industry, academia or other government agencies to support the space program; and transferring NASA technology to new applications.

“We look forward to seeing the impacts of this agreement on ISM as well as the research community. With agreements such as this, it’s particularly exciting to watch the multi-faceted benefits unfold,” says Darryl Mitchell, IPP technology manager at Goddard. ■

Opportunity for Partnership

A Revolutionary Multiple-Wavelength Light Detection and Ranging (LIDAR) System for Vegetation Mapping

NASA Goddard Space Flight Center invites companies to license its new active vegetation index measurement technique that enables remote differentiation of vegetative and non-vegetative surfaces. The first method of its kind, this patent-pending spectral-ratio biospheric *Light Detection and Ranging (LIDAR)* system uses coded signals on two lasers, enabling users to both discriminate between and monitor changes in photosynthetic surfaces. This unique process can greatly benefit environmental and agricultural mapping and monitoring as well as other commercial and government efforts.

How it works

The Normalized Difference Vegetation Index measures the reflectivity and absorption of chlorophyll-containing vegetation. Chlorophyll absorbs visible light for use in photosynthesis, illustrated by blue and red peaks near 0.4 and 0.67 μm . The leaves strongly reflect near-infrared (NIR) light from 0.7 to 1.2 μm . The transition around 0.7 μm is known as the red edge. Less reflected radiation

in red wavelengths versus NIR wavelengths indicates healthy and dense vegetation. If the difference between the intensity of the reflected wavelengths is small, then the vegetation is presumed sparse, dead or absent. Using a wavelength close to the red edge provides an unambiguous signal.

Goddard's technology provides a land-surface *LIDAR* method that uses spectral reflectance to make these determinations. The process calls for the use of two telecommunications lasers (O-band and C-band), both of which are frequency doubled, providing imaging wavelengths of approximately 665 nm and 775 nm. Light from both lasers is rapidly modulated to provide precise range information without requiring powerful short laser pulses. Calculating a ratio of the returned signals from these two wavelengths enables vertical resolution of, and differentiation between, vegetative and non-vegetative surfaces. Because the method uses two wavelengths that are absorbed differently by chlorophyll-containing (vegetative) surfaces, changes in the vegetation itself can be determined and monitored.

Why it is better

Typical imaging and mapping *LIDAR* systems use a single-wavelength approach that is capable of detecting altitude differences between the ground and objects above the ground. This difference is used to infer the height of vegetation assumed to be in the field of view, but it does not account for dead trees, rocks, buildings, or other structures. Therefore, these methods cannot readily distinguish between vegetation and non-vegetative surfaces. Precursor *LIDAR* techniques were able to discriminate vegetative ranges but could not monitor relative changes to the vegetation itself. Using other wavelengths may make it difficult to distinguish between living vegetation and some common, non-vegetative surfaces that have similar reflectance ratios.

Contrasted with these methods, Goddard's paired-wavelength approach provides a proven method that enables both determination and tracking of vegetative land surfaces.

Benefits

- **Multiple wavelength:** Uses multiple-wavelength *LIDAR*, enabling direct discrimination of vegetative from non-vegetative surfaces as well as monitoring of vegetation changes
- **Reliable:** Employs commercial off-the-shelf lasers with known reliability
- **Three-dimensional:** Provides a 3-D view of chlorophyll in plant canopies, enabling users to obtain information about surface type as well as volume

Opportunity for Partnership

- **Accurate:** Provides unprecedented information for calibration of passively acquired multispectral vegetation data
- **Proven:** Performs as expected as demonstrated during NASA testing

Applications

Goddard's technology has great potential for airborne mapping and monitoring of topography and ecosystem changes for applications such as:

- Agriculture
 - Forestry inventory
 - Precision farming
- Environmental monitoring
 - Biomass measurements
 - Habitat quality assessments
 - Ecosystem damage assessments
- Mapping
 - Surface topography beneath vegetation
 - 3-D surface details of forested flood plains and wetlands
 - Mixtures of artificial, geological and living features ■

For more information, contact
NASA Goddard's Office of
Technology Transfer,
(301) 286-5810,
techtransfer@gsfc.nasa.gov.

Please mention that you read
about it in *Technology Innovation*.

Real-Time Optical Parylene Thickness Sensor

NASA Goddard Space Flight Center invites companies to license this *Real-Time Optical Parylene Thickness Sensor* technology. This highly accurate sensor greatly improves thickness control in parylene and other polymer deposition systems, providing alerts of batch-to-batch process variations and enabling precise and repeatable controls.

Because advanced applications of thin-film parylene are limited by the precision of the deposition, enhancing thickness monitoring and deposition may facilitate new applications for this material.

With accuracy greater than 95 percent, it provides real-time measurements of deposited film thickness ranging from .5 to 30 microns. In addition, this sensor technology lowers production time and cost by reducing errors and material waste. Because advanced applications of thin-film parylene are limited by the precision of the deposition, enhancing thickness monitoring and deposition may facilitate new applications for this material.

Goddard's new *Optical Film Thickness Sensor* can be used with parylene and other polymer deposition processes. The sensor optically measures the increasing parylene film thickness on the face of the sensor head. The

polished face of the sensor head uses one or more polished optical fibers. As film deposits on the fibers, it creates a polymer Fabry-Perot cavity, which can be interrogated and measured. This measurement is directly correlated to the film thickness and maintains a thermally identical coating surface as the hardware being coated.

How it works

The sensor is secured to the coating chamber feed-through and has two optical fibers embedded into a silica base plate that has been polished to optical flatness. Light travels through the optical fibers to the base plate where the parylene film is being deposited. Because of the change in the indices of refraction, a portion of the light is reflected both where the parylene film meets the air and where the parylene film meets the optical fiber. These reflections have an optical path difference and, therefore, form an interference pattern. These resulting interference fringes are measured using basic interferometric techniques to

produce real-time, accurate measurements that are directly correlated to the film thickness. Additional fibers could be added for even greater accuracy. Because this sensor works in real time within the deposition chamber, it renders inconsequential the environmental factors experienced with other measurement techniques that affect deposition uniformity and accuracy.

Why it is better

Of the available thickness monitors, including quartz crystal oscillators and conductivity devices, none can provide the level of accuracy needed for parylene films—particularly when it is used in nanoscale devices such as microtubules and microfluidic chips.

This sensor is also versatile: In addition to parylene, it can be readily applied to other deposited films including polymers. Adaptations only require the deposited material's index of refraction.

NASA Goddard Space Flight Center is seeking patent protection for this technology.

Benefits

- **Lowers costs:** By accurately depositing the right amount of parylene dimer, costs can be controlled and even lowered since undershooting and overshooting are unnecessary. This technology uses existing hardware that is widely used in the optics industry.
- **Saves time:** Real-time processing eliminates post-deposition monitoring. Run times are shortened

because rerunning to add more material is eliminated.

- **Enables new applications:** Enhanced thickness monitoring enables the advancement of existing technologies.
- **Enables advancement toward ISO 9000 certifications:** By creating repeatable standards and reproducible measurements for film thickness, this technology can help companies advance towards achievement of ISO 9000 certification.

Applications

- **Microelectromechanical systems (MEMS):** Microscale devices such as microtubes and microfluidic and micro-optical devices
- **Automotive:** Sensors and protective

coatings for automotive electronics

- **Aerospace:** Sensors and protective coatings for electronics and other equipment
- **Electronics:** Stronger wire bonds, moisture barriers, dielectric coatings and device dielectric layers (potential)
- **Medical:** Biocompatible coatings for medical devices (e.g., coronary stents, prosthesis, catheters, etc.) ■

For more information, contact NASA NASA Goddard's Office of Technology Transfer, (301) 286-5810, techtransfer@gsfc.nasa.gov.

Please mention that you read about it in Technology Innovation.

The image shows a collage of several covers of the 'Technology Innovation' magazine, published by the National Aeronautics and Space Administration (NASA). The covers feature various scientific and technological themes, including 'FROM THE LABORATORY TO THE MARKET', 'RESEARCHER RECOGNIZED FOR ENVIRONMENTAL CLEANING TECHNOLOGY', and 'Nanotechnology Paves Way for New Business Venture'. Overlaid on the collage is the large text 'Want to Subscribe?' in a stylized font. Below this text, it says 'To comment and for more information, please visit www.ipp.nasa.gov'. The NASA logo is visible in the top right corner of the collage.

feature

NASA CENTERS WIN

R&D

100

Awards

The 44th Annual **R&D 100 Awards** recognized four **NASA** centers for excellence in research and development innovation. The technologies demonstrated in the worldwide competition are among the **most innovative ideas** from academia, government and industry.

Langley Research Center

Researchers at NASA Langley Research Center (LaRC) in Hampton, Va., have won a 2006 R&D 100 Award for development of the *Magnetic Field Response Measurement Acquisition System*.

The measurement acquisition system uses magnetic fields to power sensors and to acquire measurements from sensors. The significance of the new system is that a single sensor can be used to simultaneously measure two or more unrelated physical properties without electrically connecting to any power source or data-collecting hardware. Sensors can be designed for any measurement to take advantage of the system. The measurement system alleviates many shortcomings of traditional measurement acquisition systems. In the aerospace industry alone, wire damage has resulted in critical spacecraft launch delays, and the National Transportation Safety Board accident database includes several aircraft accidents related to wiring issues. The measurement system offers the potential to improve safety and efficiency in the aerospace industry and many other venues.

The new technology was developed over several years by Dr. Stanley E. Woodard of LaRC and Bryant D. Taylor of Swales Aerospace

PHOTO CREDIT: LARC



BRYANT D. TAYLOR, DR. STANLEY E. WOODARD AND DR. QAMAR A. SHAMS IN THE LAB WITH A FLUID LEVEL SENSOR AND THE LATEST HAND-HELD MAGNETIC RESPONSE RECORDER PROTOTYPE. THEY ARE AMONG THOSE RECOGNIZED WITH AN R&D100 AWARD FOR EXCELLENCE IN RESEARCH AND DEVELOPMENT INNOVATION.

Corporation. Dr. Qamar A. Shams and the late Robert L. Fox of LaRC also provided critical contributions to the system. The group initially worked on the technology as means for retrofitting aging aircraft with health monitoring technology for NASA's aeronautics enterprise. The researchers also received funding from the NASA Langley Creativity and Innovation program. Later, they partnered with Messier Dowty, a leading aircraft landing gear manufacturer, to demonstrate the technology to wirelessly measure fluid-levels in landing gear shock struts.

The researchers at LaRC have demonstrated numerous sensors that use the measurement system including

sensors for measuring any fluid level in any environment, wheel speed, temperature, material phase changes, proximity, position and fuel volume during vehicle pitching and rolling and tamper/damage detection. Using the magnetic field response measurement acquisition system and specially designed passive circuit sensors, accidents that previously caused explosions in fuel tanks would become a thing of the past. For example, today's aircraft use traditional electronic fuel tank sensors that can short circuit and produce sparks to ignite fuel vapors. With the new technology, this potential for accidental explosion is eliminated.

The new sensors also would be useful

to measure fluid volume in fuel tanks subjected to fluctuating orientations. Traditional fuel tank sensors are not accurate when the tank is subjected to non-level conditions. The new sensor technology can measure fluid volume, not just fluid level in a fuel tank.

The system opens up a new paradigm for detecting wear and tear in all types of mechanical systems. Magnetic field fluctuations can be used to measure wheel speed in any kind of external conditions, independent of line of sight. In the trucking industry or the automobile racing industry, this technology can monitor tire tread wear and tire pressure, and it can provide early indications of tire ply separation or belt damage. Similarly, sensors embedded in ship materials could be used to monitor hull integrity in extreme conditions. In the manufacturing industry, the technology could be used to monitor the cure process for all types of materials being produced.

The scientists and engineers who devised the magnetic field response measurement system say they enjoy the challenge of transforming their ideas into reality at NASA. The innovators are already working to apply their inventions on NASA's next generation Crew Launch Vehicle. Their measurement system could be used to help astronauts monitor the integrity of space suits and assess vehicle health. For example, the system could instantly detect damage to the vehicle caused by impacts from high velocity microscopic objects, thus enabling faster implementation of remediation

strategies.

The technology currently is not available in the marketplace, but according to Woodard, the cost of the components can be estimated. The hand-held unit, which includes housing, antenna, LCD display, frequency synthesizer and all associated hardware and software, is expected to be priced near \$250 at initial production. Once volume production begins, Woodard says the cost could reasonably fall to the \$100 range. Though sensor cost would be a fraction of a cent when built with simple circuits in mass production, more elaborately made sensors would be more expensive.

Not only does this technology enable measurements in any type of environment (including environments characterized by caustic chemicals, extreme temperatures, extreme pressures, or harmful radiation), the system also allows monitoring of multiple sensors on a single data channel and allows a single sensor to simultaneously monitor more than one physical property. According to its designers, the technology would be easy to retrofit into existing systems and is easily scalable. The invention has been awarded three patents and more are on the way.

Goddard Space Flight Center

Developed at NASA Goddard Space Flight Center, Greenbelt, Md., the *Conformal Robotic Gripper* has won a spot as one of the top 100 most unique, innovative and noteworthy technologies for 2006.

The technology is a unique gripping mechanism that has the potential to revolutionize robotics by eliminating the need for specialized end effectors and grippers. End effectors are typically designed for very specific tasks and therefore tend to be limited in the range of objects they can accommodate. The gripper's innovative design uses arrays of pins that gently conform to any object's shape then lock into position for an extremely secure, yet gentle hold—even against significant external force or torque. This enables the conformal gripper to grasp and manipulate objects of varying size and shape, securely holding an object's position for repair, machining or assembly.

"It is a true honor to have this technology recognized by R&D, and I appreciate the efforts of everyone who supported and assisted in its development," says Inventor John Vranish, researcher emeritus. Vranish also stated that continual refinements will be made to simplify operation, lower mass, and lower manufacturing costs for the gripper technology.

The *Conformal Gripper* was originally designed for use in NASA's lunar robotics missions. By using this new gripper, spacecraft carrying robots to the Moon, Mars or to repair the Hubble Space Telescope will no longer require multiple end effectors. The *Conformal Gripper* will be the only end effector needed, drastically cutting down on the robot's mass and making space robotic activities safer and more capable.

In addition to the space industry,

the gripper has applications in manufacturing and other industries that rely on robots to use tools and manipulate objects. This *Conformal Gripper* will enable superior, affordable and more productive small-batch manufacturing, which is the production of 50 or 100 items. Typically, manufacturing small quantities means automation is not possible and human participation is required, which increases costs. The conformal gripper's agility and dexterity enable it to use simple tools with superior results, making it possible to automate tasks for small-batch manufacturing without the high cost of custom end effectors.

On the surgical front, robots are assisting doctors in delicate surgery that yields more accuracy with less cutting and speedier recovery times. Precision, miniature conformal grippers can secure and operate simple tools with a sense of location, touch and feel comparable (and in some respects superior) to a human hand.

Other potential uses are in search-and-recovery activities in inhospitable environments, such as rescue missions where it is unsafe for humans to move about or bomb detection and disposal.

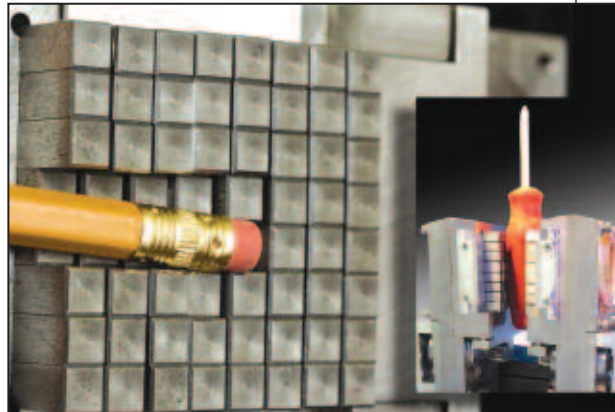
"We are extremely pleased that Mr. Vranish's *cConformal Robotic Gripper* technology was selected for this award," says Nona Cheeks, chief of Goddard's Office of Technology Transfer. "His innovative ideas and

tremendous dedication to continually improving the technology will undoubtedly revolutionize robotics in all fields."

Glenn Research Center

NASA Glenn Research Center's Communications Division, including Dr. Jeffrey Wilson, Dr. Rainee Simons, Dr. W. Dan Williams and

PHOTO CREDIT: GSFC



HONORED AS ONE OF THE TOP 100 MOST UNIQUE, INNOVATIVE AND NOTEWORTHY TECHNOLOGIES FOR 2006, THE *CONFORMAL ROBOTIC GRIPPER* USES ARRAYS OF PINS THAT GENTLY CONFORM TO ANY OBJECT'S SHAPE THEN LOCK INTO POSITION FOR AN EXTREMELY SECURE, YET GENTLE HOLD—EVEN AGAINST SIGNIFICANT EXTERNAL FORCE OR TORQUE. ONE FINGER OF THE GRIPPER IS DEMONSTRATED WITH A PENCIL, WHILE THE INSET PHOTO DEPICTS THE ENTIRE TECHNOLOGY HOLDING A SCREWDRIVER.

Richard Krawczyk (retired), collaborated with L-3 Communications Electron Technologies Inc., Torrance, Calif., on a *Traveling-Wave Tube* (TWT) that is being recognized as one of the 100 most technologically significant products introduced into the marketplace over the past year.

The L-3 Communications Electron Technologies Inc. Model 999HA is a high-power, high-efficiency space TWT that will provide high-rate communications for science data and video from deep space NASA missions. This TWT will enable sci-

ence data and video to be sent at significantly higher rates than previously possible and with reduced cost.

A *Traveling-Wave Tube* is an electronics device that is used to amplify microwave communications signals. TWTs are needed for high-frequency and high-power applications such as deep space communications because they have significantly higher power capability and efficiency than solid state devices.

The L-3 Communications 999HA TWT will enable direct-to-Earth communications at data rates 75 percent higher than previously possible while decreasing overall mass by 35 percent. It also is operational over a very wide frequency bandwidth of 9 GHz, which provides flexibility for future NASA missions.

Jet Propulsion Laboratory

Working in conjunction with a number of industry and federal agencies, NASA's Jet Propulsion Laboratory, Pasadena, Calif., helped create Explorer, a long-range, untethered, self-powered robotic system to visually inspect natural gas pipelines. The system prevents air from coming into contact with the natural gas, ensuring a reliable and safe operation. ■

For more information, visit <http://www.rdmag.com> or <http://www.nasa.gov/home>.

Please mention that you read about it in *Technology Innovation*.



NASA to Partner with AirLaunch LLC on Small Satellite Development

Exploring collaborations in space launch systems and payloads launched from aircraft is the main objective of a new partnership between NASA and AirLaunch LLC. The two entities recently signed a memorandum of understanding for the joint venture.

PHOTO CREDIT: ARC

NASA Ames Research Center, Moffett Field, Calif., is seeking partnerships to promote the development of a robust commercial space industry to benefit and support NASA's exploration, science and aeronautics mission goals. Development of small spacecraft is a primary focus of NASA Ames and it is developing a 'skunk works' to build small satellites that cost less than \$250 million.

"NASA Ames will become a West Coast 'space portal' for affordable small satellites and other scientific and commercial payloads," says S. Pete Worden, director of NASA Ames. "A small commercial launch vehicle may be a very attractive approach for providing affordable, responsive launch capabilities for biotech, lunar and other small spacecraft payloads of interest to NASA and commercial users."

Under terms of the agreement, NASA Ames and AirLaunch will explore areas of collaboration to include mission, vehicle and payload concept analyses; systems engineering; and payload integration, as well as use of NASA Ames' facilities, such as its wind tunnels, arc-jet facility, flight simulators, hangars and runways.

"We're excited to partner with NASA Ames and leverage its long history of working with innovative companies and technologies to develop a robust commercial small payload market," says Debra Facktor Lepore, president of AirLaunch LLC. "Within a few years, government and commercial customers will be able to approach NASA Ames and AirLaunch to develop and launch small payloads using the latest technologies and facilities available at NASA Ames."

AirLaunch LLC is developing the QuickReach Small Launch Vehicle (SLV) concept under a contract with the Defense Advanced Research Projects Agency/U.S. Air Force



NASA HAS SIGNED A MEMORANDUM OF UNDERSTANDING WITH AIRLAUNCH LLC, KIRKLAND, WASH., TO EXPLORE COLLABORATIONS IN SPACE LAUNCH SYSTEMS AND PAYLOADS LAUNCHED FROM AIRCRAFT. NASA AMES RESEARCH CENTER, MOFFETT FIELD, CALIF., IS SEEKING PARTNERSHIPS TO PROMOTE THE DEVELOPMENT OF A ROBUST COMMERCIAL SPACE INDUSTRY TO BENEFIT AND SUPPORT NASA'S EXPLORATION, SCIENCE AND AERONAUTICS MISSION GOALS. SHOWN DURING A SIGNING CEREMONY HELD AT NASA HEADQUARTERS, WASHINGTON D.C. ARE (L-R) DEBRA FACKTOR LEPORE, PRESIDENT OF AIRLAUNCH LLC, AND S. PETE WORDEN, DIRECTOR OF NASA AMES.

Falcon SLV program that also includes NASA participation. QuickReach is designed to meet the goals of affordable and responsive space lift, with the ability to deliver 1,000 pounds to low-Earth orbit for less than \$5 million per flight and launch within 24 hours notice. AirLaunch's rocket achieves responsiveness by launching from an unmodified C-17A or other large cargo aircraft. AirLaunch LLC is a small business headquartered in Kirkland, Wash. ■

*For more information, contact
Phil Herlth, (650) 604-0625, pherlth@mail.arc.nasa.gov.*

*Please mention that you read about
it in Technology Innovation.*

NASA Ames Air Traffic Management Tool Wins Software of the Year Award

NASA software designed to help improve the safety and efficiency of the national airspace system has been recognized for its innovation and significant contributions to science and technology.

The Future - Air Traffic Management Concepts Evaluation Tool (FACET), developed at NASA Ames Research Center, Moffett Field,

Calif., was selected as NASA's 2006 Software of the Year. *FACET* is a flexible software tool that provides powerful simulation capabilities and can rapidly generate thousands of aircraft trajectories to enable efficient planning of traffic flows at the national level.

"I'm absolutely thrilled that the Ames team has been honored with this prestigious award," says NASA

Ames Center Director S. Pete Worden. "As a center, we have enjoyed tremendous success in previous NASA Software of the Year competitions; this award adds to our proud legacy and is a harbinger of great things to come for our center."

FACET uses actual air traffic data from the Federal Aviation Administration (FAA) and weather information provided by the National



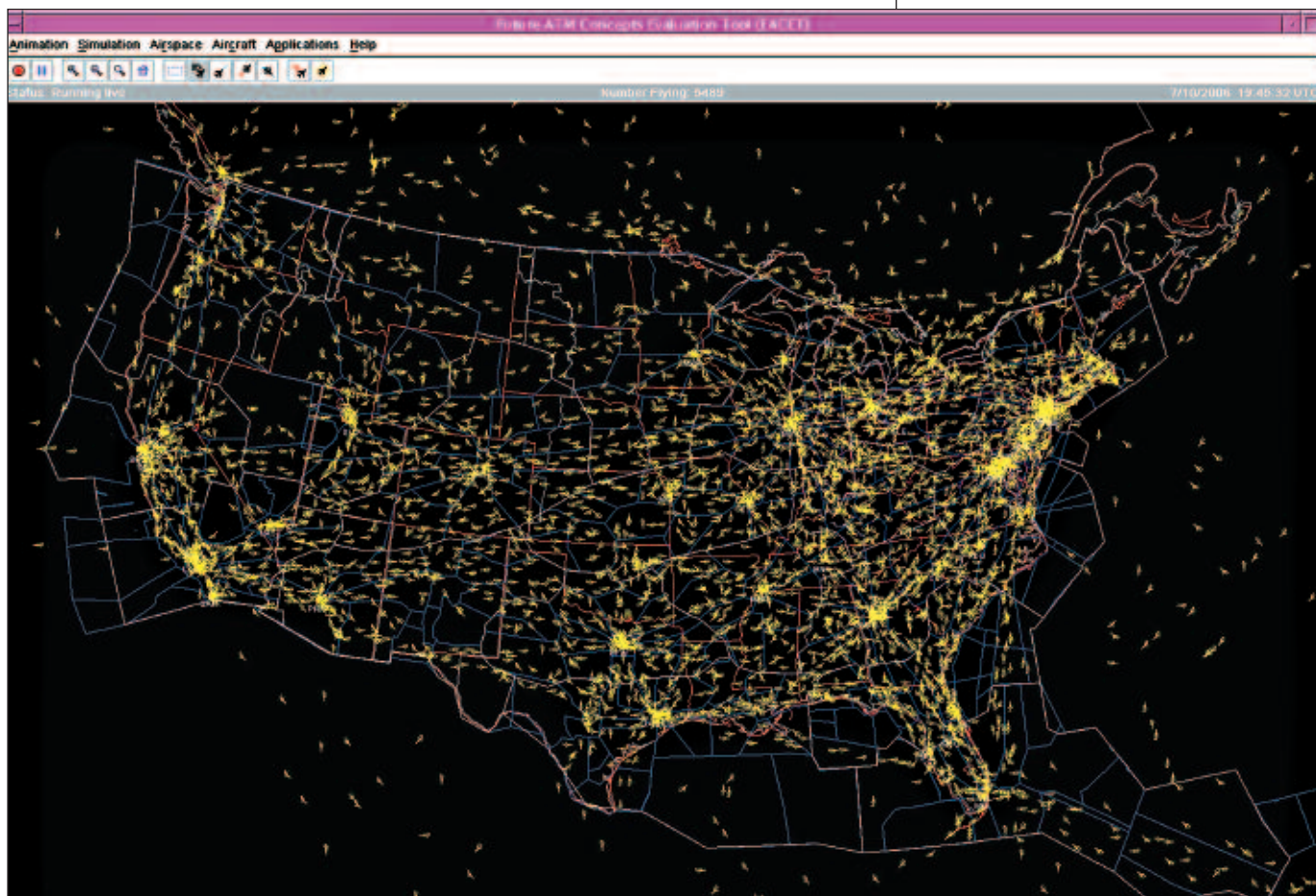
Oceanic and Atmospheric Administration (NOAA) to analyze the flight plan route and predict trajectories for the climb, cruise and descent phases of flight for each aircraft type. According to NASA Ames engineers, the analyses of these trajectories drive the various air traffic management applications. This innovative feature enables *FACET* to model airspace operations at the U.S.

national level, and process more than 15,000 aircraft on a single desktop or laptop computer. For the commercial airline passenger, this holds the promise of more frequent on-time departures and arrivals.

"*FACET* started out as a simulation tool for NASA research and has evolved into an operations planning tool for the FAA and airlines," says NASA Ames' Banavar Sridhar,

FACET team lead. "I would like to thank our colleagues for supporting and contributing to this successful endeavor."

FACET has transitioned successfully from NASA laboratory theoretical use to national operational use. Technologies derived from *FACET* have been incorporated into the FAA's traffic management system, which is used currently by more than



A FACET snapshot of air traffic over the United States on July 10, 2006 at 2:45 p.m. EST. FACET, developed at Ames Research Center, was selected as NASA's 2006 Software of the Year.

500 air traffic managers at approximately 100 sites nationwide. NASA has commercially licensed the *FACET* software to Flight Explorer®, Washington, a leading vendor of flight operations management tools that are used by nearly 5,000 dispatchers at more than 600 customer sites including 80 percent of major United States airlines. *FACET* is a component of a growing suite of air traffic management tools developed at NASA Ames as part of the NASA Airspace Systems Program at NASA Headquarters in Washington.

The Software of the Year Award, developed by the NASA Inventions and Contributions Board, recognizes outstanding contributions in software development. Selection is based on a rigorous set of criteria including the software's significance to science and technology, its impact on NASA's mission, quality, usability, extent of potential use and innovation. All software must be licensed and commercially available.

"Making NASA mission technologies applicable and available to meet the needs of the American public, industry and academia increases the

value added from the taxpayer's investment in the U.S. space program," says Robin Orans of the Technology Partnerships Office at NASA Ames. "The licensing of *FACET* is helping make air travel safer and more efficient by saving fuel for airlines and time for passengers from gate to gate." ■

For more information, contact Robin Orans, (650) 604-5875, rorans@mail.arc.nasa.gov.

Please mention that you read about it in *Technology Innovation*.

NASA

Did you know?

An interesting fact to stimulate the mind

What rescue tool was developed through the joint efforts of NASA, the Hi-Shear Technology Corporation and firefighters?

Lifeshears

Lifeshears is a powerful, hand-held rescue tool that can quickly cut through cars or other enclosures to free people involved in an accident or other dangerous situations. Lifeshears were used by rescue workers searching for survivors in the Oklahoma City Federal building in 1995 and the World Trade Center in 2001. The tool uses the same power source used to separate solid rocket boosters from the space shuttles. Lifeshears are lighter, cheaper and easier to use than traditional rescue equipment.

This partnership was significant in that it allowed by design the continued support for production of pyrotechnic initiators prolonging their availability for multistage launch vehicles. This is a cost saving to NASA and nation by keeping a limited source product available through the innovative use in an additional commercial product.



Goddard's Detector Systems Facility

Goddard Space Flight Center's Detector Systems Facility in Greenbelt, Md., is home to three well-equipped labs where detectors have been designed, built and tested for NASA's spacecraft, aircraft, balloons and rockets, as well as Earth-based telescopes. These labs also are available for use by other government, academic or commercial entities, which enables access not only to Goddard's state-of-the-art facility, but also to a highly experienced team of engineers who have proven abilities for providing cutting-edge detector solutions.



A NASA EMPLOYEE WORKS WITH THE MASK ALIGNERS AND WAFER BODER AT GODDARD SPACE FLIGHT CENTER'S DETECTOR SYSTEMS FACILITY. THESE LABS AT GSFC ARE AVAILABLE FOR USE BY OTHER GOVERNMENT, ACADEMIC OR COMMERCIAL ENTITIES.

The capabilities and expertise of the Detector Systems Facility and Goddard's staff are well demonstrated in the successful projects that have been undertaken for NASA. Major successes include the following:

- Infrared (IR) camera for the New Horizons mission to Pluto
- Large-format two-dimensional addressable microshutter array for the James Webb Space Telescope
- Silicon wire bridge chips and polysilicon IR sources for the Spitzer Space Telescope
- World's largest operational far IR bolometer array
- Low-noise cryogenic junction gate field-effect transistors (JFETs) for Gravity Probe B
- World's first large-format gallium-nitride (GaN) ultra violet (UV) detector array
- HgCdTe infrared detector array for the Cassini mission to Saturn
- World's first 1Kx1K gallium arsenide and wideband quantum well IR photodetector (QWIP) arrays

Specific areas of expertise in the labs include detector physics, microfabrication, detector characterization and engineering of high-performance detector systems. A project can be developed from the initial concept through the design, build and characterization phases all the way to final application.

Those seeking assistance from the Detector Systems Facility will be provided with a highly experienced team of engineers dedicated to helping find innovative, custom detector solutions that are space-qualified, robust in hostile environments and ultra-reliable.

Detector Development Laboratory (DDL)

The DDL is a microelectronics fabrication facility dedicated to the development of advanced detectors, microelectromechanical systems (MEMS), nanotechnology, circuits and components. The laboratory is built around a 4,800-square-foot Class 10/100 cleanroom housing an extensive array of semiconductor processing equipment to perform full-scale custom wafer fabrication. The laboratory also offers a large

variety of fabrication equipment for optical and electron-beam lithography, wet and dry etching, oxidation, thin-film deposition of metals and dielectrics, ion implantation, indium bump bonding, wafer bonding, mechanical and laser wafer dicing, superconductor material fabrication, thin film metrology and device characterization.

Detector Characterization Laboratory (DCL)

This facility offers complete optical and electrical characterization of large-format detector arrays operating in the UV, visible and IR spectrums. The laboratory actually consists of several laboratories, including Class 100 and 10,000 cleanrooms for testing contamination-sensitive detectors and subsystems. Current measurement capabilities include readout noise, dark current, charge-transfer efficiency, absolute quantum efficiency, spatial resolution and modulation transfer function (MTF). Flight-qualification testing capabilities include radiation tests and ultra-low background testing in the IR with two specially built cryostats. The DCL also provides general-purpose reconfigurable detector array control and data acquisition electronics, blanket optical illumination and spot scans, flat-field uniformity and extensive data analysis.

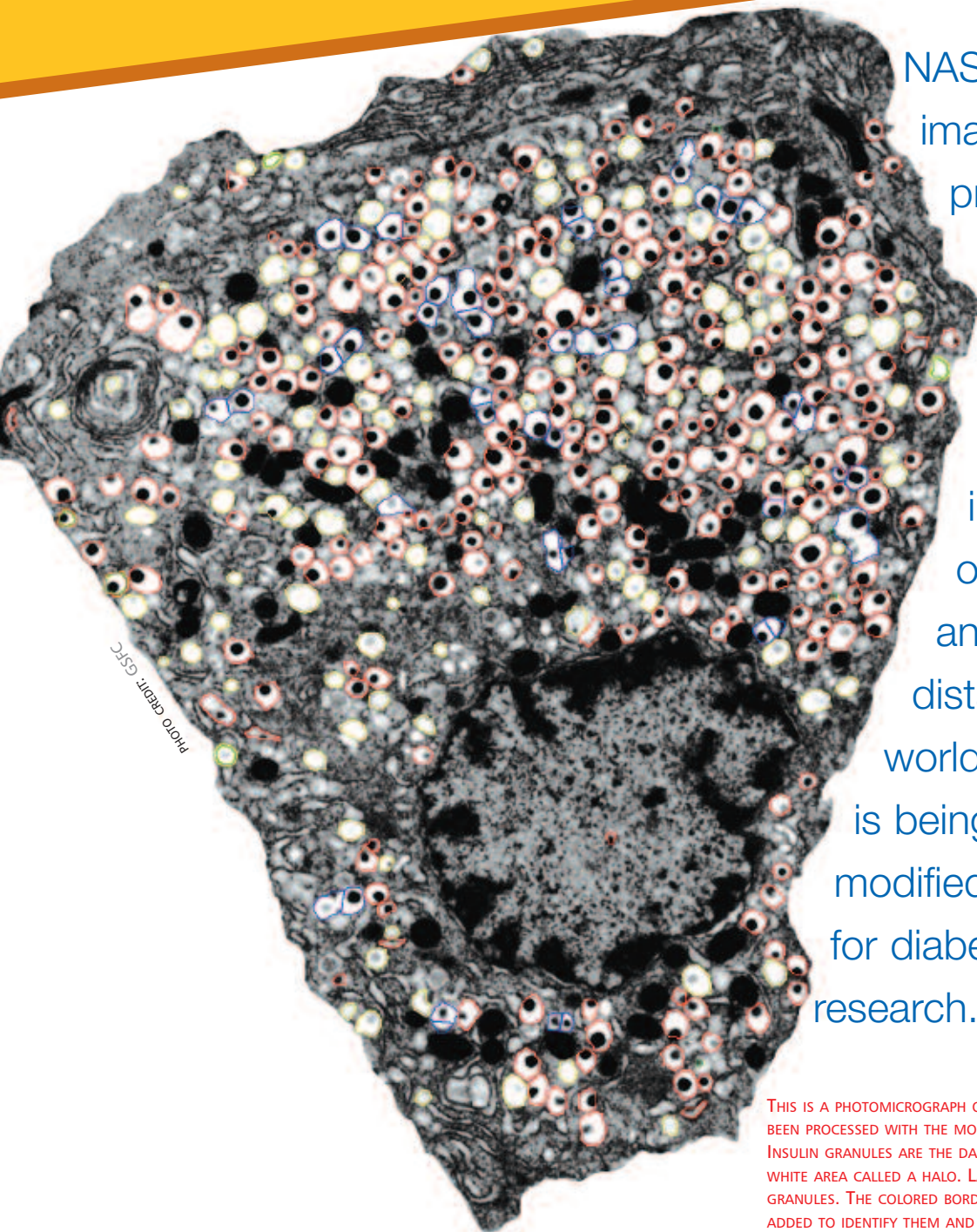
Superconducting Detector Test Facility

The purpose of the facility is to develop and test superconducting (and other cryogenic) detectors operating at temperatures below 1 Kelvin. Dilution and Helium-3 refrigerators provide access to ultra-low temperatures. Sensitive instrumentation allows measurements of detector material properties and functional performance at frequencies ranging from direct current to microwave. ■

For more information, contact Carl Stahle, (301) 286-0968, Carl.M.Stahle@nasa.gov or visit <http://detectors.gsfc.nasa.gov>.

Please mention that you read about it in Technology Innovation.

NASA and Universities Join Fight Against Diabetes



NASA image processing technology used to explore orbital images of Earth and distant worlds is being modified for diabetes research.

THIS IS A PHOTOMICROGRAPH OF A SLICED RAT BETA CELL THAT HAS BEEN PROCESSED WITH THE MODIFIED NASA IMAGING TECHNOLOGY. INSULIN GRANULES ARE THE DARK BLACK SPOTS SURROUNDED BY A WHITE AREA CALLED A HALO. LARGE CELLS HAVE HUNDREDS OF INSULIN GRANULES. THE COLORED BORDERS AROUND THE GRANULES ARE LABELS ADDED TO IDENTIFY THEM AND CLASSIFY HOW THEY APPEAR.

Scientists at The George Washington University, Washington, and Cornell University, Ithaca, N.Y., helped modify the technology, which has greatly increased the speed of the research.

“NASA technology combined with our modifications has provided us with new tools for fighting diabetes,” says Murray Loew, director of the Biomedical Engineering Program and professor of

Type II diabetes, either pancreatic cells don’t secrete enough insulin, or cells in the body lose their responsiveness to insulin, or both problems happen at once. Both types of diabetes cause glucose to build up in the blood instead of being delivered to the interior of cells, where it is needed or would be stored. Life-threatening effects include coma, heart disease, kidney damage, nerve damage, blindness and loss of limbs.

graphs overnight,” says Tim McClanahan, a scientist at NASA’s Goddard Space Flight Center in Greenbelt, Md.

“We plan on an extensive collaboration in the future. The potential for this research is excellent,” says Geoffrey Sharp, a diabetes expert in the Department of Molecular Medicine at Cornell University. The team has submitted proposals to the National Institutes of Health and the

“NASA technology combined with our modifications has provided us with new tools for fighting diabetes.”

—Murray Loew

engineering at The George Washington University’s School of Engineering and Applied Science.

Diabetes afflicts more than 20 million Americans. It is caused by the body’s inability to regulate glucose, a sugar that cells use for energy. The hormone insulin regulates blood glucose levels by unlocking the interior of cells and allowing glucose in blood to pass through the cell wall. Insulin is manufactured in beta cells in the pancreas. Microscopic structures called granules carry insulin toward the cell wall of the beta cells, where it is secreted in response to glucose levels in the blood.

Two types of diabetes exist. In Type I diabetes, pancreatic cells are destroyed. In

In the research, the team analyzed electron photomicrographs (images from an electron microscope) of beta cells from rats.

The original NASA technology helps scientists to classify image elements (pixels) and identify different types of landforms, geology and vegetation. In the laboratory, it’s been adapted to identify biological structures, the insulin granules, in electron photomicrographs. The research team observed the number, size, and position of insulin granules in the beta cells in response to glucose.

“Previously, the analysis of each electron micrograph took an assistant several hours to complete. Now, with the image processing software, we can automatically analyze several dozen electron micro-

American Diabetes Association to further validate the technology with additional data and to extend the work to identify and characterize other microscopic cellular structures.

The research is being funded by Goddard’s Part Time Graduate Study Program, NIH and the Juvenile Diabetes Research Foundation. ■

For more information, contact NASA Goddard’s Office of Technology Transfer (301) 286-5810, techtransfer@gsfc.nasa.gov

Please mention that you read about it in Technology Innovation.

A Commercialization Plan

NASA seeks partnerships with U.S. industry and the venture capital community that supports NASA's technology needs. Once it is decided which partnering option best suits an organization, a commercialization plan must be prepared in accordance with invention licensing regulations. The following information should be included in the application:

- Identify the invention for which a license is desired.
- Please indicate type of license being applied for.
- Identify the applicant. Give the name and address of the person, company or organization applying for the license. Where applicable, give citizenship, place of incorporation and the name of the parent corporation.
- List the name, address and telephone number of the applicant's representative with whom correspondence should be held. The representative should have authority to conduct licensing negotiations.
- Describe the nature and type of applicant's business. The description should include any products or services that the applicant has successfully commercialized and the approximate number of people employed by the applicant. Many license applicants submit a company annual report to comply with this paragraph.
- Explain how the applicant became aware of the subject invention.
- Indicate whether the applicant is a small business firm. "Small business firm" means a small business concern as defined in the regulations of the Small Business Administration.

- Provide a detailed description of the applicant's plan for development and/or marketing the invention. At a minimum, the plan should include:
 - o A statement of anticipated investment of capital and other resources the applicant believes will be necessary to bring the invention to practical application. This statement shall include the nature, amount and timing of such anticipated investments.
 - o A statement indicating the applicant's capability and intention to fulfill this plan for development and/or marketing. With regard to the applicant's capability, this statement shall include information pertaining to the applicant's manufacturing, marketing, financial, and technical resources, with balance sheet, income statement and an annual report as attachments. With regard to the applicant's intention, this statement should include a timeline of key steps or milestones the applicant believes will be required to bring the invention to practical application.
 - o A statement of the fields of use in which the applicant intends to practice the invention.
 - o A statement of the geographic areas in which the applicant intends to manufacture any products embodying the invention and the geographic areas where the applicant intends to use or sell any products embodying the invention.
- Identify any licenses that were previously granted to the applicant under any federally owned inventions.

- Provide a statement containing the applicants best knowledge, pertaining to the extent the invention is being practiced by private industry, the government or both and the extent the invention is commercially available.
- Provide any other information the applicant believes will support a determination to grant the requested license to the applicant.

The financial attachments are an extremely important part of the application. They will be held in confidence as proprietary documents. ■

For more information, about how to prepare a Commercialization Plan, email technology@dfrc.nasa.gov.

Please mention that you read about it in Technology Innovation.



Innovative Research

Sensing the Future — *A Technology Evolves*

Finding deadly gas leaks is critical and can often be difficult, especially in advanced, complex systems. But a small, high-tech firm, called Makel Engineering Inc. (MEI) in Chico, Calif., produces sensing technology that makes the job easier.

MEI's motto is "Sensing the Future," and based on the technology they have designed and developed for NASA, that motto is right on target.

For about 10 years, MEI has partnered with NASA through the Agency's Small Business Innovation Research (SBIR) and Small Business Technology Transfer Programs (STTR) at several of NASA's 10 Centers. Most of the SBIR and STTR awards have focused on leak-detection systems for major missions and programs.

In the mid-1990s, NASA was interested in hydrogen-sensing technology for a number of its future aerospace programs. Under an SBIR contract from Kennedy Space Center, MEI built a sensor technology for detecting hydrogen leaks. The original research for the system had actually started with an earlier STTR contract at Marshall Space Flight Center (MSFC), with Case Western University in Ohio as MEI's partner. These programs led to the development of a system that flew onboard the space shuttle and eventually contributed to several other NASA programs. Around the same time, the firm also designed and built a 40-sensor detection system for NASA's

X-33 program. Although the X-33 never left the ground, the MEI system was space-qualified.

For its next project, MEI worked on the development of safety sensors for NASA's X-43 vehicle, under an SBIR contract from MSFC. The company had to take a new approach to meet the unique requirements of the very space-limited vehicle. President and founder Darby Makel says, "There was an evolution over time. If you look at the X-33 systems they were relatively large sensors that were connected back to a central-processing unit. There are different specs for each vehicle because they have different requirements and different



PHOTO CREDIT: MAKEL ENGINEERING INC.

THE FLIGHT HYDROGEN SENSOR ORBITAL REPLACEABLE UNIT WAS BUILT FOR THE OXYGEN GENERATING SYSTEM ON THE INTERNATIONAL SPACE STATION.

EXAMPLES OF HOW NASA IS WORKING WITH SMALL BUSINESSES

missions. Even though you

have a core technology, it requires some retooling.”

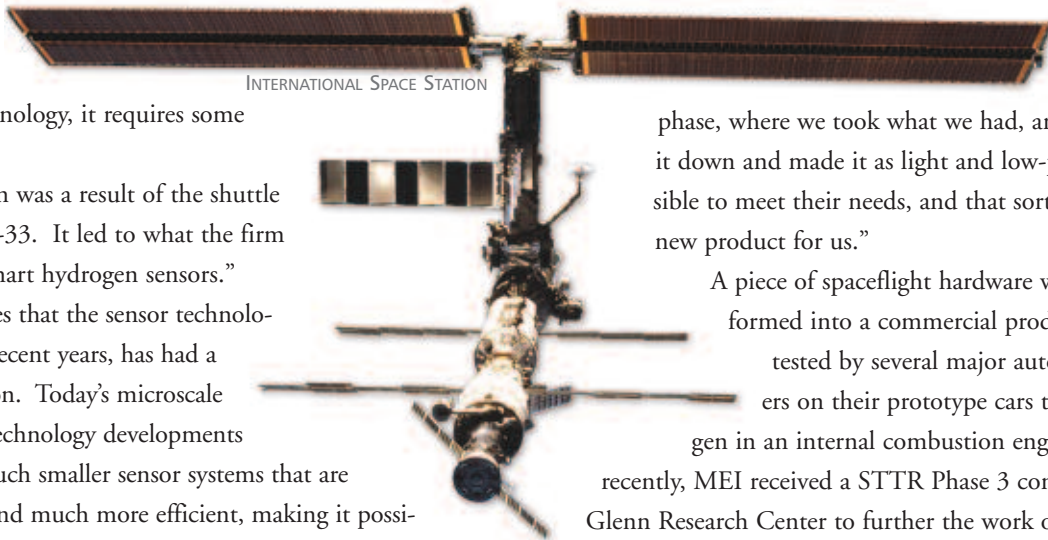
The evolution was a result of the shuttle work and the X-33. It led to what the firm now calls its “smart hydrogen sensors.”

Makel believes that the sensor technology industry, in recent years, has had a second revolution. Today’s microscale and nanoscale technology developments have enabled much smaller sensor systems that are more sensitive and much more efficient, making it possible to tailor systems to very specific chemicals. These technology developments also have made it possible for firms like MEI to produce much smaller systems, such as the one on the X-43.

Currently, NASA is putting an Oxygen Generation System (OGS) on board the International Space Station. The system uses water to create breathable oxygen for the crew by separating oxygen and hydrogen from the water. While the oxygen will add crew capacity, the hydrogen will be vented to the outside. A critical part of the system is a triple-redundant sensor package, designed and built by MEI. The sensors will work in parallel to monitor hydrogen levels. Periodically, the package will be returned to the firm for recalibration to ensure accuracy and reliability.

When NASA flight-tested the unique lightweight Helios aircraft, it was powered by a fuel cell system using hydrogen. On board was a low-cost, miniaturized hydrogen leak-detection system designed and built by MEI, working closely with the vehicle integrator, Aerovironment and Dryden Flight Research Center. During the development phase of the system for Helios, MEI was not faced with the constraints of space-flight qualification, so again the firm approached the work differently and had unexpected results.

According to Makel, “We went through a small engineering



phase, where we took what we had, and we stripped it down and made it as light and low-power as possible to meet their needs, and that sort of evolved a new product for us.”

A piece of spaceflight hardware was transformed into a commercial product now being tested by several major auto manufacturers on their prototype cars that use hydrogen in an internal combustion engine. More recently, MEI received a STTR Phase 3 contract from Glenn Research Center to further the work originally done for Marshall.

“The work we’ve done for Glenn has focused on basically taking the sensors both for hydrogen and also for oxygen, and now we’re branching into other species, but primarily those two, and making very miniaturized leak detection systems,” says Makel.

The new systems will be wireless, will use low power and will be small enough to be placed in any location. MEI hopes to integrate the new systems into exploration vehicles for NASA.

Today, as the company continues to “sense the future,” it is developing a chemical system for a new generation of self-powered rovers and vehicles for planetary exploration through an SBIR award from Johnson Space Flight Center. ■

For more information, contact Dr. Kumar Krishen, (281) 483-1348, Kumar.Krishen-1@nasa.gov.

Please mention that you read about it in Technology Innovation.

Did You Know?

An interesting fact to stimulate the mind

In 1995, what sporting good company looked to NASA for assistance in making improvements to one of their products?

Wilson Sporting Goods

Wilson Sporting Goods incorporated a design on their golf balls that uses NASA aerodynamics research to create its Ultra™ 500 Series. The 500 dimples on the ball are arranged in a patter of 60 spherical triangles of different sizes, shapes and depth. Earlier golf balls had about 20 triangular faces. Research showed that the size and placement of these patterns made a difference in how well the golf ball soared through the air.

NASA Innovative Partnerships Network

NASA Field Centers

NASA Headquarters

Doug Comstock
Washington, DC 20546
202/358-2560
doug.comstock@nasa.gov

Ames Research Center

Information Technologies, Aerospace Systems, Autonomous Systems for Space Flight, Nanotechnology, Space Life Science/Biotech, Computational Fluid Dynamics and Aviation Operations

Lisa Lockyer

Ames Research Center
Moffett Field, CA 94035
650/604-1754
llockyer@mail.arc.nasa.gov

Dryden Flight Research Center

Aerodynamics, Aeronautics Flight Testing, Flight Systems, Revolutionary Flight Concepts, Thermal Testing, and Integrated Systems Test and Validation

Gregory Poteat

Dryden Flight Research Center
Edwards, CA 93523
661/276-3872
greg.poteat@dfrc.nasa.gov

Glenn Research Center

Aeropropulsion and Power, Communications, Information Technology, High-Temperature Materials Research, Microgravity Science and Technology, including Bioengineering, and Instrumentation and Control Systems

Kathleen Needham

Glenn Research Center
Cleveland, OH 44135
216/433-2802
Kathleen.K.Needham@nasa.gov

Goddard Space Flight Center

Earth and Planetary Science Missions, LIDAR, Cryogenic Systems, Tracking, Telemetry, Command, Optics and Sensors/Detectors

Nona Cheeks

Goddard Space Flight Center
Greenbelt, MD 20771
301/286-5810
nona.k.cheeks@nasa.gov

Jet Propulsion Laboratory

Deep and Near Space Mission Engineering and Operations, Microspacecraft, Space Communications, Remote and In-Situ Sensing, Microdevices, Robotics and Autonomous Systems

Ken Wolfenbarger

Jet Propulsion Laboratory
Pasadena, CA 91109
818/354-3821
james.k.wolfenbarger@jpl.nasa.gov

Johnson Space Center

Life Sciences/Biomedical, Medical

Michele Brekke

Johnson Space Center
Houston, TX 77058
281/483-4614
michele.a.brekke@nasa.gov

Kennedy Space Center

Fluid Systems, Spaceport Structures & Materials, Process & Human Factors Engineering, Command, Control & Monitoring Technologies, Range Technologies, Biological Sciences

David R. Makufka

Kennedy Space Center
Kennedy Space Center, FL 32899
321/867-6227
David.R.Makufka@nasa.gov

Langley Research Center

Aerodynamics, Flight Systems, Materials, Structures, Sensors, Measurements and Information Sciences

Marty Waszak

Langley Research Center
Hampton, VA 23681
757/864-4015
m.r.waszak@nasa.gov

Marshall Space Flight Center

Materials, Manufacturing, Non-Destructive Evaluation, Biotechnology, Space Propulsion, Controls and Dynamics, Structures and Microgravity Processing

Vernotto McMillan

Marshall Space Flight Center
Huntsville, AL 35812
256/544-2615
vernotto.mcmillan@msfc.nasa.gov

Stennis Space Center

Propulsion Systems, Test/Monitoring, Remote Sensing and Non-Intrusive Instrumentation

John Bailey

Stennis Space Center
Stennis Space Center, MS 39529
228/688-1660
john.w.bailey@nasa.gov

NASA Business Facilitators

NASA has established several organizations whose objectives are to establish joint-sponsored research agreements and incubate small startup companies with significant business promise.

Greg Hinkebein

Mississippi Enterprise for Technology
Stennis Space Center, MS
228/688-3144

Heidi Brandow

Florida/NASA Business Incubation Center
1311 N. U.S. Highway 1
Titusville, FL
321/267-5601

Richard Reeves

Business Technology
Development Center
Huntsville, AL
256/704-6000, ext. 602

Small Business Programs

Carl Ray

NASA Headquarters
Small Business Innovation Research Program (SBIR/STTR)
202/358-4652
cray@hq.nasa.gov

Paul Mexcur

Goddard Space Flight Center
Small Business Technology Transfer Program (SBIR/STTR)
301/286-8888
paul.mexcur@pop700.gsfc.nasa.gov

NASA-Sponsored Technology Transfer Organizations

These organizations were established to provide rapid access to NASA and other federal R&D agencies and to foster collaboration between public- and private-sector organizations. They also can direct you to the appropriate point of contact within the Federal Laboratory Consortium. To reach the organization nearest you, call 800/642-2872.

Darwin Molnar

National Technology Transfer Center
Wheeling, WV 26003
800/678-6882

Dan Winfield

Research Triangle Institute Technology Applications Team
Research Triangle Park, NC 27709
919/541-6431

Want to subscribe?

Contact us!

To comment and for more
information, please visit

www.ipp.nasa.gov

National Aeronautics and
Space Administration

Innovative Partnerships Program
Washington, DC 20546-001

Official Business
Penalty for Private Use \$300

FIRST CLASS MAIL
POSTAGE & FEES PAID
NASA
PERMIT NO. G27